Structural Usage Monitoring and Flight Regime Recognition

Presented by

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The Team

- PI – Dr. Richard "Pat" Anderson, ERAU, Aviation Science
- Co-PI – Dr. Andrew J. Kornecki, ERAU, Computer and Software Engineering
- ERAU Aerospace Engineering and Software Engineering graduate students (Rachel Rainicek, Sam Prem, Stephen Risoff)
- Systems and Electronics (SEI), industry partner
- Embry-Riddle's Eagle Works, flight-test facility

Project Overview

- The scope of the contract is a three year effort with total funding of $621k equally spread over each year; this effort will result in the following research outputs:

  1. A summary of the current state-of-the-art in structural usage monitoring and flight regime recognition algorithms

  2. An analysis of the current technology level (TRL) and capabilities of Commercial Off The Shelf (COTS) systems

  3. An analysis of the required level of technology to meet the certification guidance in AC 29-2C, Chg 1, MG 15

Objectives and Goals

- The objective of the contract is to move a HUMS system for Usage Monitoring (UM) from a technology readiness level of 6 (system/subsystem prototype demonstration) to level 8 (operational qualified through test and demonstration)

- The core prototype is SEI's Structural Integrity Monitoring System (SIMS)

- The final (three year) goal is to qualify a variant of the SIMS, through test and demonstration, for UM under the guidance of AC-29-2C MG-15

- The objective of the current phase is to prepare base for working prototype and establish documentation support for a mock-up certification

Overall Budget and Expenditures

- The project is at the mid-point and is on budget and on time.
- Major equipment expenditures include the SIMS equipment from SEI. This equipment was delivered to ERAU in December and January. Currently, ERAU has all equipment that has been listed on POs.
- Additional, mission specific equipment and COTS computer equipment will be ordered this month.
- All equipment expenditures will fall within the contract specifications.

Technical Issue and Concerns

- At present, there are no major technical issue or concerns. The majority of the preparation in the 2nd year is the generation of documentation related to the mock certification. Currently, this include the development of system requirements document, hardware and software requirements document and the test plan.

Project Status

- Completed the Annual Technical Report summarizing the Year One progress through October 2006 including Compliance Assessment
- Currently in the second fiscal year with a start date of October 1st, 2006
- Three intermediate reports on the following subjects:
  - System Requirements for the case study
    - Narrowed the selected parameter set and determine required sensors for the case study
    - Determined approximate sensor locations on the selected Bell and Schweizer helicopters
  - HW and SW Requirements for the case study
  - Test Plan and Test Cases for the case study

Project Status

- The second year began with completing an AC-29 compliance assessment which demonstrated that there are no show stoppers with the SEI equipment
- A system requirements document has been created based upon the case study to eliminate the 100hr inspection tail rotor RTB
- The hardware and software requirements are being created based upon the system requirements
- The SEI equipment still has no show stoppers and should be ready for bench testing in May 2007

Project Status

- Completion of the top-level system requirements (end-to-end system) focused on eliminating the 100hr inspection tail rotor RTB

- The system requirements categorized into general, onboard, and ground categories.

- The analysis has shown that there are no top level show-stopper in the use of a modified SEI SIMS in the case study

- The team is currently completing the hardware and software requirements documents derived from the system requirements and again indicate no show stoppers with the SEI SIMS

- The onboard processing and storage units and the transfer unit for ground station interface received from the SEI in Jan/Feb 2007

Roadmap to May 2007 Deliverables

Target Dates

Jan 30

Feb. 28

March 31

April 30

May 31

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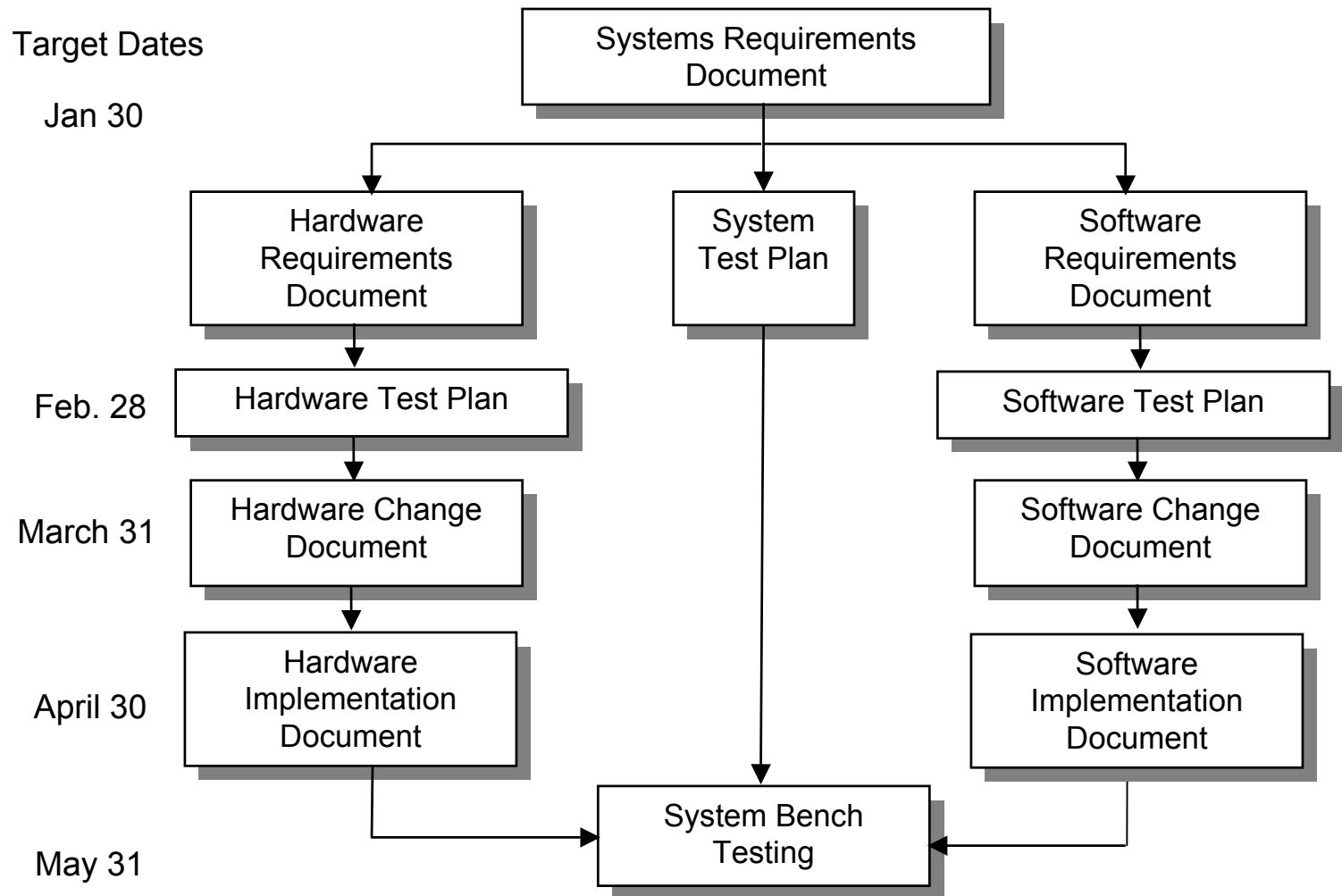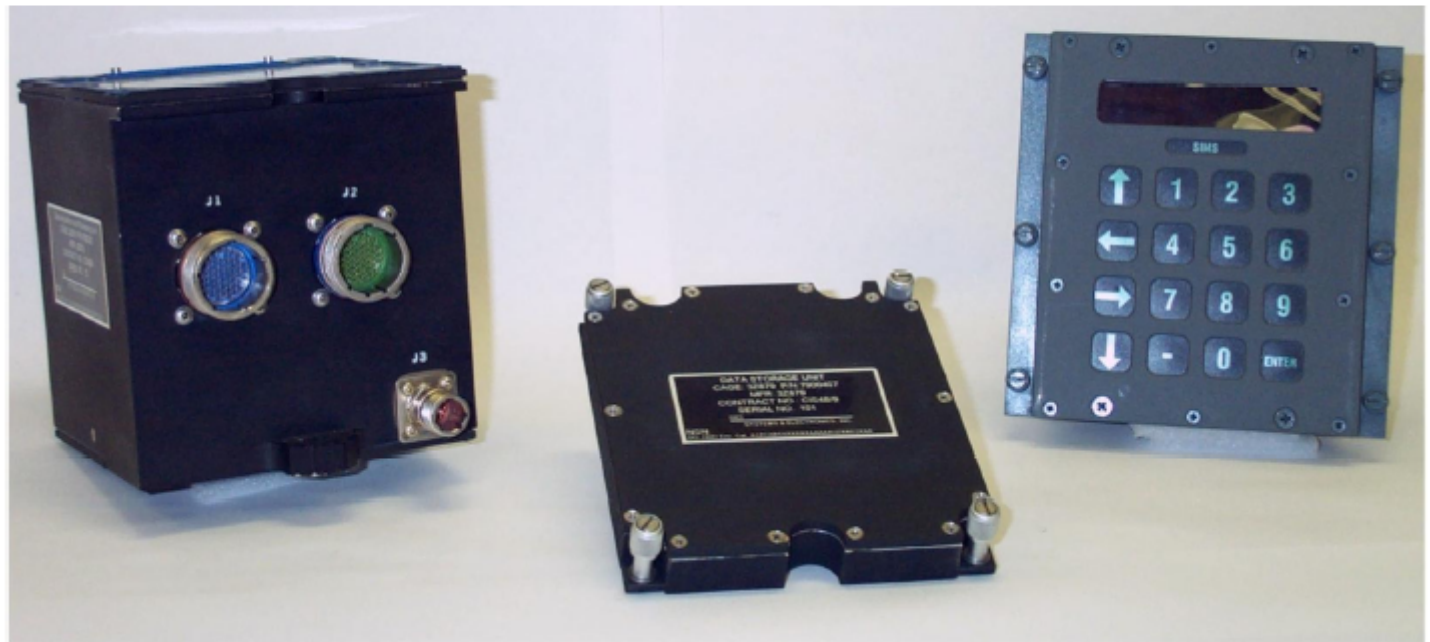
Acquisition and Processing Unit, Data Storage Unit, Display Unit

Hardware Received: Ground

DTIU Data Transfer Interface Unit

Case Study

- The maintenance credit utilized in the project is the elimination of the 100 hour inspection tail rotor (TR) track and balance (TB)
- The HUMS will be used to determine if the vibrations on the tail rotor are within the manufacturer's specifications:
  - If the vibrations are within specifications then no track and balance will be required
  - If the vibrations are not within specifications a track and balance will be performed prior to the next flight of the rotorcraft, this may require a track and balance to be performed before or after the 100 hour inspection

Parameters and Sensors

- Several parameters have been identified which will allow the team to both eliminate the 100hr TRTB as well as observe additional flight regimes.

- The sensors to track the required parameters have also been identified.

- Approximate onboard sensor locations have been determined.

Parameters and Sensors

Parameter	Units	Transducer Needed	Sample Rate Req'd	Equipment Max Sample Rate	Interface	Manufacturer
Gross Weight	lbs	Pilot Input	6Hz	----------------	CDU	SEI
Altitude	ft	INS	6Hz	100Hz	RS232	NovAtel
Outside Air Temp	°F	Single Channel OAT A-1	6Hz	analog	analog	Electronics Int.
Airspeed	knts	PPT-Differential	6Hz	120Hz	RS232	Honeywell
Rotor speed	**rpm**	**Tachometer**	**6Hz**	**analog**	**analog**	**Honeywell**
WOW	**-------**	**Microswitch**	**6Hz**	**--------------**	**analog**	**Honeywell**
Vertical Velocity	ft/s	INS	6Hz	100Hz	RS232	NovAtel
Roll Angle	deg	INS	6Hz	100Hz	RS232	NovAtel
Pitch Rate	ft/s	INS	6Hz	100Hz	RS232	NovAtel
Vertical Acceleration	ft/s^2	INS	6Hz	100Hz	RS232	NovAtel
Time	**UTC**	**GPS**	**5Hz**	**5Hz**	**RS232**	**NovAtel**
Collective Stick Position	**inches**	**String Pot**	**6Hz**	**analog**	**analog**	**Sensotec**
Lateral Cyclic Position	inches	String Pot	6Hz	analog	analog	Sensotec
Longitudinal Cyclic Position	inches	String Pot	6Hz	analog	analog	Sensotec
Pedal Position	inches	String Pot	6Hz	analog	analog	Sensotec
Tail Rotor Vibration	**ips**	**Velocimeter**	**6Hz**	**analog**	**analog**	**Chadwick**
Note: Bolded items are required for 100hr RTB elimination						

Transducers

- Chadwick-Helmuth Velocimeter is currently used in OEM maintenance practice

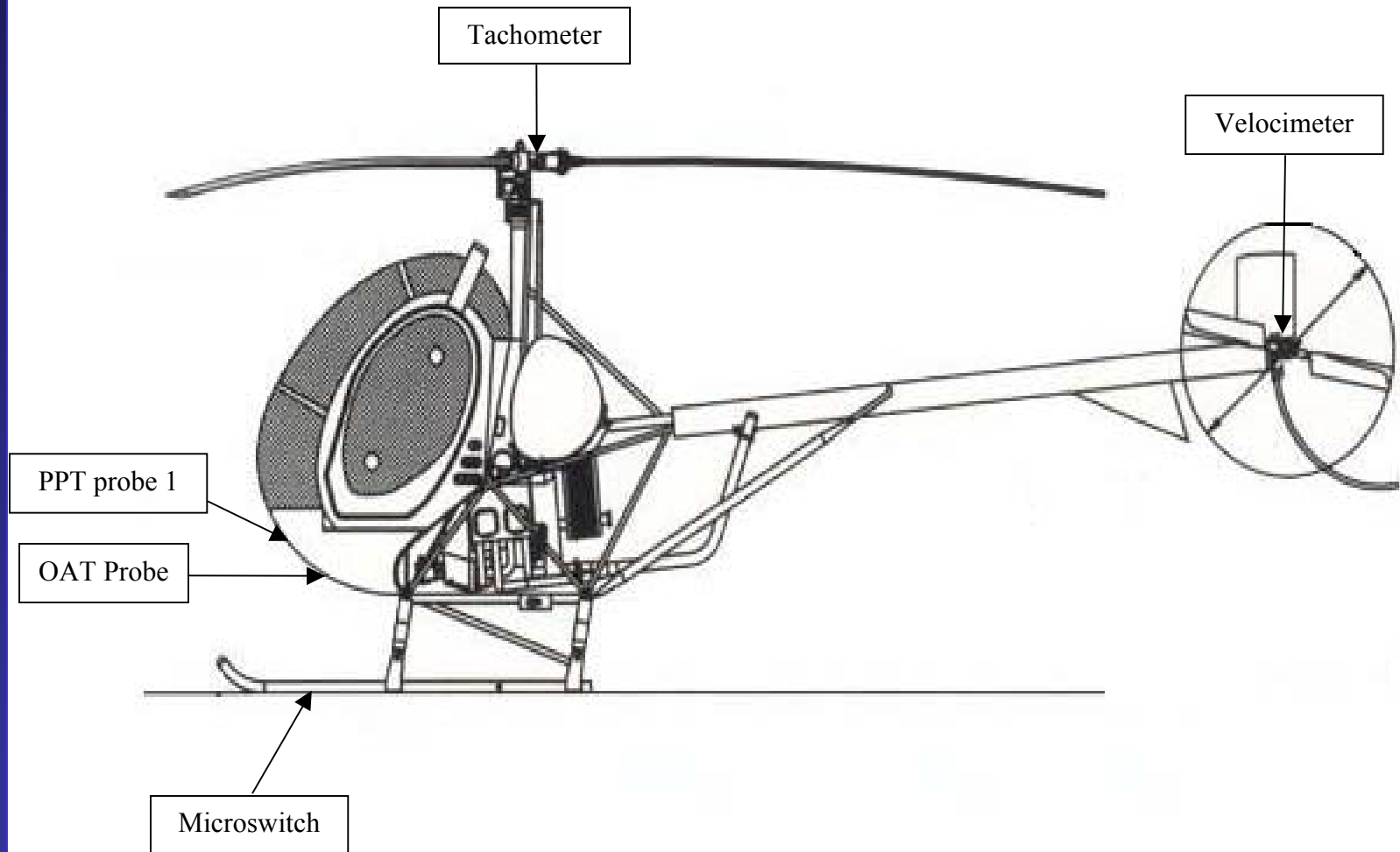- HeliTune TRVWS will allow monitoring of two Chadwick transducers for multiple frequency ranges

Transducer Set-Up

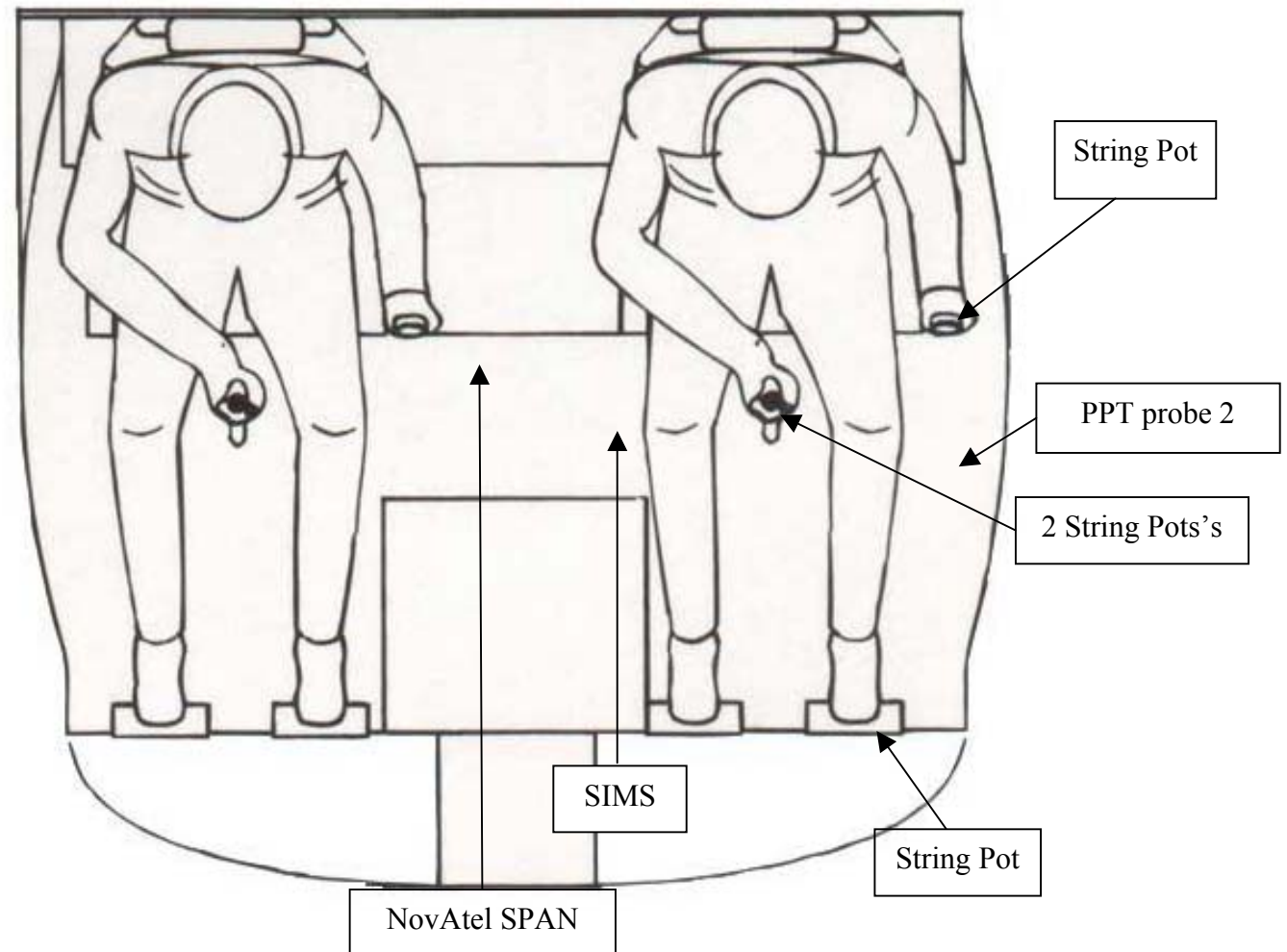- For current OEM practices the transducer is affixed to the helicopter as shown
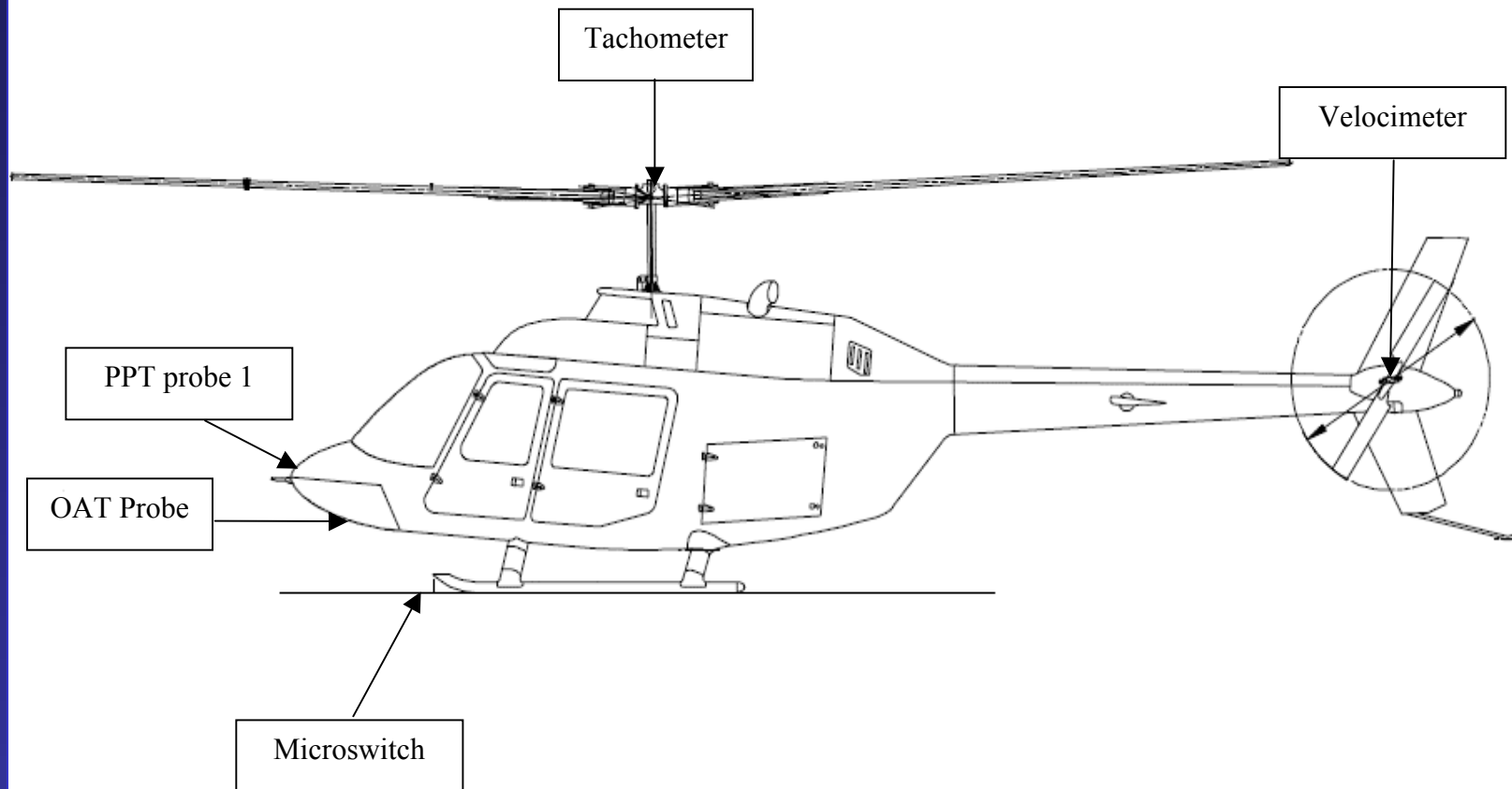
External Sensor Locations– Schweizer 300

Tachometer

Velocimeter

PPT probe 1

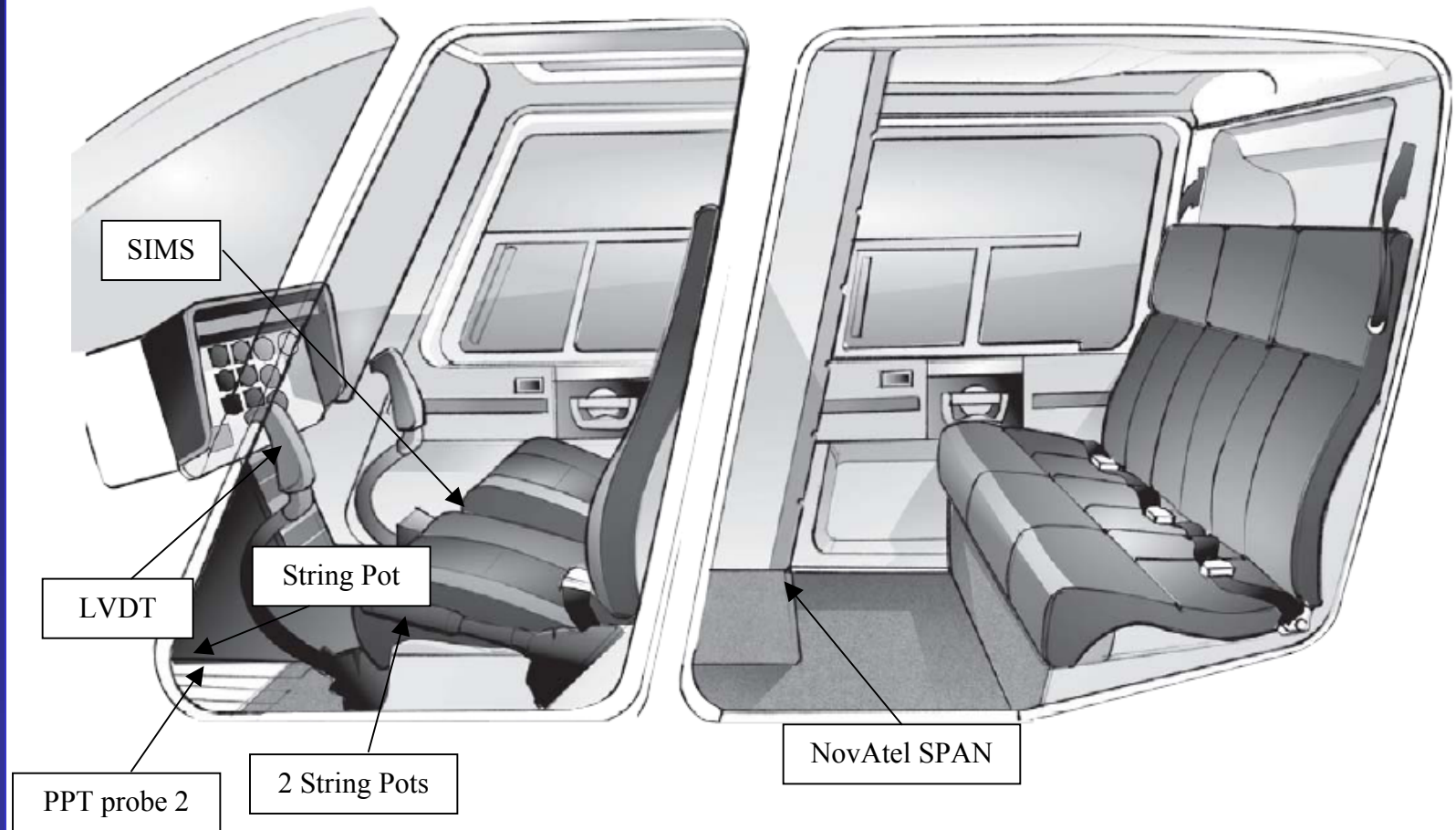OAT Probe

Microswitch

Internal Sensor Locations— Schweizer 300

External Sensor Locations– Bell 206

Internal Sensor Locations– Bell 206

SIMS

LVDT

String Pot

PPT probe 2

2 String Pots

NovAtel SPAN

Next Phase

- The next phase of this contract (March 2007) is the development of System, Hardware, and Software Test plans

- The project will continue along the current roadmap until the May 17th, 2007 deliverables are completed

- These deliverables will include a Technology Refinement and Implementation Report as well as a report detailing the preliminary results of Bench Testing

- Additional hardware required to facilitate project completion must be purchased from SEI